# Chapter 3
# Economic, Legal and Social Aspects of Post-Fire Management

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## 3.1 Introduction

In the past, wildland fires mainly caused concern amongst resource managers and local communities that were directly affected by these disastrous events. However, in the last decades the increasing attention paid by the media to large scale fires that occurred in different parts of the world and their consequences also triggered increased concern among the general public. These major fire events also clearly showed that they are not only an environmental problem, but are of significant social dimensions, affecting millions of people, having major economic impacts and causing significant human casualties (González Cabán 2007). For example, the wildfires affecting vast forest areas of Portugal in 2005 caused damages worth almost 800 million € and took 13 lives. Even worse, the large fires affecting Greece during the summer of 2007 caused 64 casualties and damages estimated to be worth over five billion €. The social aspect of forest fires is further underlined by the fact that around 90% of forest fires in Europe are caused by people (Velez 2009).

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The increased public interest and concern about fires also prompted the responsible agencies to develop and implement improved policies and management measures at different levels, which should minimize the negative environmental, economic and social impacts of forest fires (EU 2005). However, the implementation of such measures requires substantial investment of financial, human and organizational resources, which must be justifiable and efficient.

Like any other type of resource management, also post-fire management should be based on three main pillars: ecological, economic and social. Trying to simplify the roles of the three pillars, we could say that the ecological characteristics of an area indicate its present state, vulnerability to different impacts, limitations in the development of management objectives and applicability of management practices. The social aspects will facilitate the identification of relevant stakeholder groups, their needs and preferences, potential conflicts, traditions, institutional set-up and acceptability of certain management measures. Finally, the economics helps to evaluate the efficiency and distributional effects (equity) of feasible management alternatives. Therefore, limiting management decisions on only one of the mentioned pillars can considerably jeopardize the success and the effectiveness of implemented management measures. Rather, the effort should be made that post-fire interventions reflect a balance between the mentioned aspects.

While the rest of this book mainly focuses on the influence of environmental conditions on post-fire management and restoration, this chapter will look at the economic and social aspects that should be considered when applying post-fire management measures.

## 3.2 Economic Aspects of Post-Fire Management

From an economic perspective, a forest fire (as any other forest disturbances) can be considered as an event that interrupts or reduces the flow of forest goods and services provided by the forests (Holmes et al. 2008). Namely, forests are providing a wide range of goods and services that contribute significantly to the welfare of societies (Farrell et al. 2000). However, a forest's capacity to provide these goods and services depends on its characteristics (e.g., health status, growing stock, location, management objectives), which in the case of a forest fire are very often significantly changed. How a forest fire can affect the flow of goods and services is illustrated in Fig. 3.1. We assume that initially a forest was providing quantity $Q_0$ of a good. Without a fire the forest would be able to secure this level of the good over the whole period (line A). However, if we assume that at $t_1$ a fire would affect the forest and its capacity to provide the good, the provided quantity of the good would decrease to $Q_1$.

After a fire a forest may recover its potential to provide goods and services in an amount as it was before the fire. For example, in Fig. 3.1 we assume that the forest would recover his full potential to provide the good at $t_2$, following line B. This would mean that as a consequence of the fire during the period $t_1$ to $t_2$ we would suffer a loss of the good equal to the area shaded in light and dark grey.

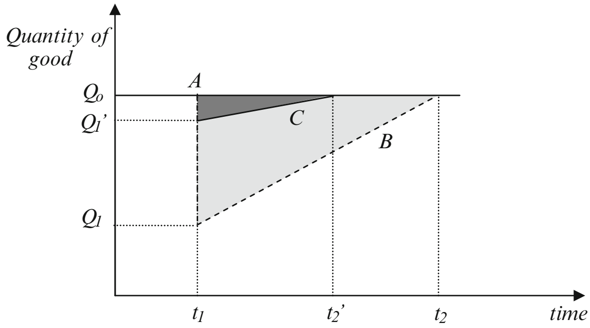


**Fig. 3.1** Illustration of effect of fire on the quantity of a forest good, its recovery process, and the effects of post-fire management practices. For further explanations, see text

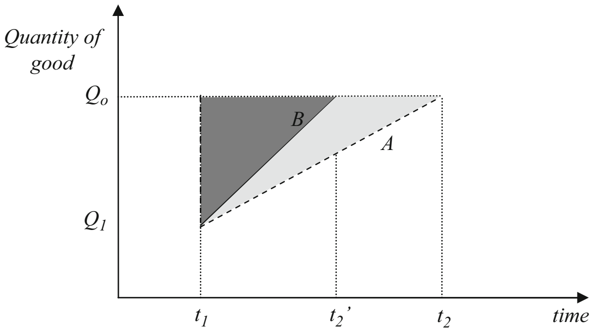


**Fig. 3.2** Illustration of the accelerated recovery process of a forest good as a result of post-fire management measures

On one hand, the effect of the fire on the flow of goods and services depends mainly on the use of the forest before the fire (i.e., which goods and services it provided), fire severity and size, and management measures taken before (prevention), during (suppression) and after (post-fire measures) the fire. Furthermore, it should be also acknowledged that in most cases multiple goods and services are affected simultaneously. For example, the reduced biomass of a forest can at the same time have negative consequences for wood production (net annual increment), carbon sequestration, soil protection, biodiversity, etc.

On the other hand also the recovery process depends on various factors, such as type of good, fire severity and size, and post-fire management measures. The post-fire management measures are mainly aimed at preventing further loss of the flow of certain goods and services, and shortening the recovery period. Figure 3.2 shows an example of how we can represent the effects of post-fire management on the recovery of the provision of a certain good.

We assume that initially the forest was providing $Q_0$ of a good. At $t_1$ as a consequence of fire the flow of the good was reduced to $Q_1$. Next, if no post-fire management measures would have been applied, it would take until $t_2$ that the same quantity of the good would be provided as before the fire. On the contrary, if post-fire management measures would be applied the recovery period would have been reduced to $t_2'$. This means that in this example, without post-fire management we would lose the total amount of the good that equals the sum of the light and dark gray areas; while in the case of post-fire management the loss would be equal to the dark gray area.

To summarize, how the post-fire management influences the recovery process depends on the type and timing of the implemented measures. Managers have in most cases various alternatives as to how to treat a forest after a fire event. Decision on which of them is going to be implemented, depends on the management objectives that should ideally be based upon the ecological, economic and social criteria. From an economic perspective the post-fire management alternatives are evaluated according to the (i) economic efficiency and (ii) distributional effects.

### *3.2.1 Economic Efficiency of Post-Fire Management*

In economics, efficiency is the most often used criterion for evaluating whether a situation or change could be improved in social welfare terms. In this respect the so-called Pareto criterion (Arrow and Hahn 1971; Mas-Colell et al. 1995), considers a new situation as preferable, or a change in the allocation of resources efficient, if someone's welfare could be improved without diminishing the welfare of anyone else. A somehow more relaxed criterion is the Hicks-Kaldor criterion (Hicks 1939; Kaldor 1939), which assumes that a new situation would be socially preferable (more "efficient") if the welfare of some people can be improved, and the winners could potentially compensate those who would lose some welfare, and still be better off. This chapter adopts the label efficiency in terms of the latter meaning, which corresponds to the one applied in cost-benefit analysis.

When addressing post-fire management alternatives, the economic efficiency[1] measures their total contribution to society's welfare. As the most efficient, we would consider the alternative that has a bigger positive contribution to the social welfare.

The methodology which is commonly applied to evaluate the contribution of a certain management option is the Cost Benefit Analysis (CBA).[2] CBA is a technique

[1] This differs from the term cost efficiency, which measures how well the inputs in a production process are used to produce a fixed set of outputs.

[2] For an overview of alternative and complementary evaluation methods see for example EFTEC (2006).

for the assessment of the relative desirability of competing alternatives (e.g., alternative post-fire management measures). In most cases the assessment involves the comparison of the current (base case) situation to one or more alternatives. For example, if one is interested in evaluating the social welfare impact of regeneration as a post-fire measure for a particular forest, the base case (without regeneration) would be compared to the alternative scenario (with regeneration). The analysis would focus on the differences in costs and benefits, in the situations with and without regeneration. The CBA compares the costs and benefits measured in monetary terms.

Benefits (the positive impacts) refer to the increases in the quantity or quality of goods or services that generate positive utility[3] or a reduction in the price at which they are supplied. The costs (negative impacts) stand for any decreases in the quality or quantity of such goods or services, or increases in their price. The costs also include the usage of resources (e.g., costs of the implementation of post-fire management measures) in the alternative, since they cannot be simultaneously used in any other way.

It is important to acknowledge, that in contrast to other evaluation methods where the costs and benefits can be expressed in different units, in a CBA all the benefits and costs are valued in monetary units. The resulting net benefits from the alternatives will reflect the summation of the changes in the net income of the society as a whole from undertaking an alternative compared with the decision of not undertaking it or undertaking a different one.

An important concept of the CBA is additionality, which refers to the net impacts of the project (Hanley and Spash 1993). This means that the costs of the project that are relevant for the assessment are those that would be incurred if an alternative is undertaken, but that would not be incurred otherwise. Similarly, the benefit of an alternative is the extra amount of a good (e.g. money, time, etc.) that would be gained if the project were undertaken rather than not undertaken (Sugden and Williams 1978).

Another central feature of the CBA is that it can compare benefits and costs that appear at different stages of a project (management alternative), by converting them into a common metric, their present value. This process is called discounting and it is based on the fact that the individuals have time preferences between consumption in different periods. The rate at which an individual is willing to exchange the present consumption for the future consumption is called the discount rate. The higher is the discount rate, the greater preference is given to the present consumption.

The CBA can be conducted from a private or a social perspective. A private CBA considers only the costs and benefits of the analyzed change which are imposed onto or accrue to a private agent (e.g. individual or firm). Thus, it considers only (market) costs and benefits, which are transmitted through prices and would affect agents directly involved (consumers and providers) in the implementation of the considered alternative. This approach is also often called financial appraisal.

[3] In economics, utility is a measure of relative satisfaction.

On the contrary, a social CBA attempts to assess the overall impact of a project on the welfare of the society as a whole. Thus, it also considers external (market and non-market) costs and benefits, which are mostly not transmitted through market transactions and are affecting parts of the society not directly involved in the implementation of the alternative (externals). Thus, a social CBA differs from the private in terms of both (i) the extent of the identification and evaluation of inputs and outputs, and (ii) the measure of costs and benefits.

Forest fires in most cases affect the welfare of wide range of stakeholders (private and externals). For example, they can affect the benefits forest owners obtain from a forest (e.g., timber), but also the benefits for the rest of the society, like ecosystem services (e.g., recreation, carbon sequestration, biodiversity) that are mostly not traded in conventional markets, but nevertheless they contribute to the societies welfare. Hence, for the evaluation of efficiency of post-fire management alternatives a social CBA should be applied; where all the cost and benefits of the analyzed alternatives are considered.

For the implementation of a social CBA of post-fire management measures we would need at least the following information: (i) type and quantity of lost goods and services as a consequence of the fire, (ii) the value of all the lost goods and services, (iii) the recovery pattern and period for each of the affected goods and services, (iv) the impact of post-fire management alternatives on the recovery pattern and period for each of the affected goods and services, and (v) the costs for each post-fire management alternative. The subsequent sections focus on those issues. Regarding the general application of a CBA we suggest the reader consults some specialized literature (e.g. Hanley and Spash 1993).

#### 3.2.1.1 Fire Impacts on Goods and Services

Forest fires impact a wide range of goods and services. An important concern in estimation of fire related impacts is the proper consideration of environmental (forest) goods and services that might have been damaged (or enhanced) as a consequence of a wildfire. In estimating the economic impacts of fires, only a few of them have traditionally been considered, mainly the decreased quantity/quality of timber.

However, in the last decades it has become obvious that forests are also important as providers of environmental and social goods and services (Farrell et al. 2000). For example, a recent review of economic assessments of fire damages (JRC 2009) found that the major part of the total damage can be ascribed to the loss of different environmental goods and services, like biodiversity, recreation, and soil protection (Fig. 3.3). This emphasises the importance of including a broad range of goods and services when estimating the fire induced damages, and in particular the consideration of both market and non-market goods and services.

Thus, nowadays, estimating the impacts of fires should include the following categories: (i) environmental goods and services that represent the benefits humans derive directly or indirectly from forest ecosystems functions (e.g. wood, biodiversity,

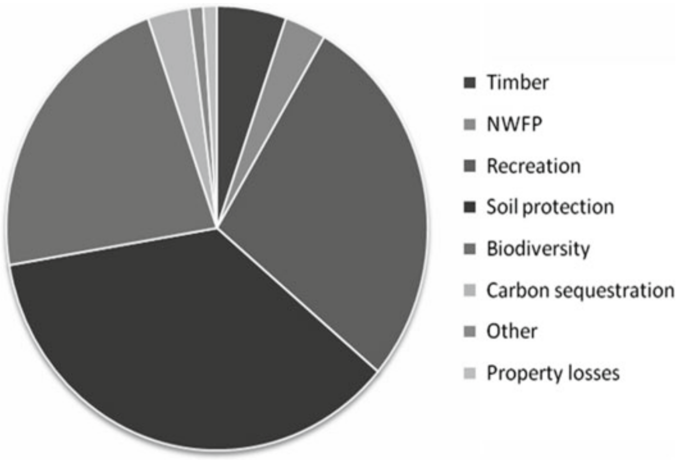


**Fig. 3.3** Average shares of the damages to different goods and services in fire damage studies

recreation); (ii) property, which includes all property directly impacted in a forest fire, such as structures (e.g. houses, cottages, buildings, and infrastructure), personal property (e.g. cars, furnishing, cloths), and production capacities (e.g. agricultural and other machines, transportation means); and (iii) direct health impacts, because forest fires often produce significant health impacts that can result in morbidity or mortality (e.g. fire fighters or residents), and can be suffered locally or on a broader scale (e.g. smoke and air pollution). Although we mostly speak about damages that are provoked by forest fires, it should be noted that the effects of fires can be also beneficial for the provision of certain goods (e.g., fodder production).

In the next section we present an overview of the impacts that forest fires can have on goods and services that were identified to be affected in previous studies.

### Timber

The value of standing timber is one of the main categories when estimating the impacts provoked by wildfires (González-Cabán 1998). For example, Abt et al. (2008) reported that in the case of four studied wildfires timber losses were around 20% of all costs and losses. However, the magnitude of timber losses can differ significantly from case to case (JRC 2009). Stand characteristics (e.g. tree species, composition, stand structure) (González et al. 2007; Velez 2000) play a determinant role in determining fire damages and therefore the losses owed to the fire.

Wildfires can have short-and long-run effects on timber and timber markets. Short-run effects (1–2 years) include the immediate destruction of valuable standing timber, and in particular after bigger events, economic disequilibrium associated with the flooding of markets with salvaged timber. The big amount of salvaged timber drives prices downward temporarily, which affects owners of the killed timber, owners of undamaged timber, and timber consumers. Long-run effects on

timber markets can arise from the loss of a large portion of standing volume, a loss that tends to drive prices upward for extended periods and produce an extra income for owners of undamaged timber. However, fires also can create conditions favourable for a reduction in timber demand. Therefore, large-scale catastrophes often redistribute wealth among producers and consumers and cause a net economic loss (Prestemon and Holmes 2004).

Hence, when calculating timber damages various aspects must be considered. On the short term, at least quantity and value of the lost timber should be taken into account, where the value is based on market prices. On the long term the quantity and the value of future lost timber production (because of decreased increment) should be considered (Zybach et al. 2009).

### Non-Wood Forest Products

Non-wood forest products (NWFP) consist of goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests (FAO 1999). Forests provide a great diversity of NWFP like cork, edible mushrooms, pine nuts, acorns, resins, medicinal plants, among others. According to the Millennium Environmental Assessment (Hassan et al. 2005) *"At least 150 NWFPs are of major significance in international trade."* Especially in the Mediterranean area non-timber forest goods can be a major income resource (Merlo and Croitoru 2005).

The high diversity of NWFP is also reflected in the different effects that forest fires have on the quantity and/or quality of them. For example, fires can improve the understory forage and grazing (Wade and Lunsford 1988), or it can decrease the availability of fruits, like pine nuts and acorns (Molina et al. 2009). Therefore, in general we cannot assume that all the NWFP production is always damaged.

Unlike the case of timber, the production of particular NWFPs is site specific, and thus, it cannot be generalised to all fire affected areas. To estimate the loss of NWFP, data about the size of the affected area, production capacity, market price and harvesting costs for each NWFP are needed.

### Recreation

Recreation refers to organised or free activities that contribute to human health and well-being. These services include walking, hunting, mountain biking, etc. Because forest fires affect the biotic and abiotic characteristics of forests, subsequently they also affect the potential of these forests to provide non-market benefits, like recreation (González-Cabán 1998). There is still no consensus as to how recreation use changes immediately after a forest fire or during the restoration period (Loomis et al. 1999).

The impact of fires on forest recreation demand has been evaluated from two perspectives (Englin et al. 2008). The first approach estimates the losses in the recreation-tourism related economic sectors of local economies (e.g. food and lodging), that are impacted upon during and after the fire (Barrio et al. 2007; Butry et al. 2001).

The second approach is directed towards the estimation of impacts of wildfires on recreation demand and the value of recreational sites (Loomis et al. 2001).

Similar to NWFPs, forest recreation is limited in its extent. To estimate the economic impacts of forest fires on recreation, the relevant area for recreation activities in the affected forest must be estimated. Furthermore, site-specific data on the number of forest visits and value per visit are needed to accurately estimate recreation losses. To estimate the later, in most cases non-market valuation methods[4] are applied (Loomis et al. 2001).

### Soil Erosion

Soil protection is mainly based on the structural aspects of forests. The vegetation root system and cover play an important role in soil retention and formation. Soil retention is assured by the root system, which stabilises the soil, and foliage, which intercepts rainfall, preventing soil compaction and erosion. On the other hand, soil formation is also supported by the root system that disintegrates the rocky material, while the vegetation cover plays an important role in the fertilisation processes.

The impacts of fire on soils can manifest themselves in significant changes in soil physical, chemical, or biological properties. These include breakdown in soil structure, reduced moisture retention and capacity, development of water repellence, changes in nutrient pools cycling rates, atmospheric losses of elements, offsite erosion losses, combustion of the forest floor, reduction or loss of soil organic matter, alterations or loss of microbial species and population dynamics, reduction or loss of invertebrates, and partial elimination (through decomposition) of plant roots (Beyers et al. 2005). The same authors also claim that impacts of fire on soil are a function of fire severity.

To assess the damages related to soil erosion, we need to estimate the affected area, the level (a function of fire intensity/severity) and quantity of lost soil,[5] and the value of lost soil. To value the damages of soil erosion different approaches can be taken. For example, the study by Görlach et al. (2004) estimates the total costs of soil degradation, considering both private and social costs and also on-site and off-site impacts of soil degradation. A different approach was applied by Mavsar and Riera (2007) estimating the social value of reduced soil erosion in Spain.

### Carbon Emissions

Forests have the capacity to directly influence the composition and the chemical balance of the atmosphere (e.g. $CO_2/O_2$ balance, maintenance of $O_3$ level and $SO_X$ level).

[4] See also Sect. 3.2.1.2.

[5] For an example see http://eusoils.jrc.ec.europa.eu/library/themes/erosion/ClimChalp/Rusle.html

This service includes clean air provision and prevention of diseases. One of the specific services, related to gas regulation, is *carbon sequestration*. By capturing and storing the excessive carbon dioxide from the atmosphere, forests contribute to the mitigation of global warming. In the last decade, this service attracted significant attention of policy makers.

In this respect fires have two main impacts. On one hand, air pollution effects of fires include emissions of particulate, noxious gases and $CO_2$, visibility impacts to road and air transportation, public health effects, property damage, and compromised recreation opportunities (Zybach et al. 2009). In light of climate change and its consequences, one of the fire effects drawing most attention is $CO_2$ emission and their economic impacts. Fires account for approximately one-fifth of the total global emissions of carbon dioxide (Sandberg et al. 2002). However, in the European context, annual emissions are only about 0.22% of the total greenhouse gas emissions in the European Union (EEA 2009). On the other hand, the decreased biomass production also influences forests present and future capacity to sequester carbon.

Therefore, to assess the damages from increased carbon emissions from fires, data on the affected area, growing stock and carbon value are needed. For the estimation of the losses related to decreased carbon sequestration capacity, the lost biomass production (e.g., net annual increment) and the value of carbon should be included. In both cases, the value of carbon can be estimated by using the voluntary market prices for carbon credits (e.g. www.endscarbonoffsets.com, http://www.ecosystemmarketplace.com).

### Biodiversity

Biodiversity is an essential factor in sustaining the functioning of the ecosystem and hence underpinning for many other forest goods and services. It generally encompasses different levels, like genetic diversity or differences of genes among populations/individuals of the same species (e.g. varieties of crops), species diversity refers to the variety of plants, animals and micro-organisms in an ecosystem and ecosystem diversity refers to the variety of different ecosystems. According to Mayer (1995) forests are the most important terrestrial ecosystems for conservation and protection of biodiversity.

The impacts of fires on biodiversity can vary significantly and are in general dependent on fire type, severity, intensity, size and frequency, and species characteristics (Brown and Smith 2000; Smith 2000). To estimate the economic impact of losses associated with biodiversity we have to consider the extent of the biodiversity loss (e.g., number of damaged specimens, species or ecosystem types) and the economic value of the respective biodiversity element (e.g., value of specimen). The later is in most cases estimated by applying non-market valuation methods.[6]

[6] For more details about non-market valuation methods see Sect. 3.2.1.2.

### Health

Forest fires can have significant impacts on public health (Zybach et al. 2009). These impacts can be the result of direct exposure to the fire or due to increased air pollution (Rittmaster et al. 2006; Zybach et al. 2009) and can occur on- and off-site.

Fires produce a number of air pollutants; some like concentrations of particulate matters (PM) can increase substantially during wildfire episodes and can have significant mortality and morbidity impacts (Butry et al. 2001; US.EPA 2004). However, it is difficult to estimate the extent of these impacts. Not all wildfire health impact studies find statistically significant impacts of wildfire induced PM contamination (Kochi et al. 2008).

The health outcomes that the fire impacts can cause are mortality, restricted activity days (including work days lost), hospital admissions, respiratory symptoms and self-treatment (Kochi et al. 2008). To estimate the health related economic impacts of fires, we need to estimate the changes in number of mortality or morbidity cases that were caused by the fire and the monetary value of these changes. The assessment of the total change of mortality/morbidity is less complicated when considering the direct exposure to fire, but is challenging in the context of increased air pollution (Kochi et al. 2008).

Concentration response models provide information on changes in health risks associated with changes in pollutant concentrations. Economic methods are used to translate these changes in risks into economic (monetary) values. These economic values are calculated in various ways. The value of health effects include the costs of illness as reflected in hospital costs and lost wages as well as the individual's willingness-to-pay to avoid the change in risk, over and above the costs of illness (Rittmaster et al. 2006). The monetary value of preventing mortality is measured as aggregated society's willingness-to-pay to save one anonymous person's life (e.g. Navrud 2001; Dickie and Messman 2004; Kochi et al. 2008).

### Property

In addition to the loss of environmental goods and services, forest fires also cause property losses (Riera et al. 2008). These might comprise private as well as public assets of different types, including homes, rural buildings and structures, businesses, infrastructure, and other goods (Butry et al. 2001; Ciancio et al. 2007; Riera et al. 2008). The value of such losses is estimated mainly through market prices. Nevertheless, the estimation of these losses is often difficult to determine, because of missing data or restricted data access (Butry et al. 2001; Kent et al. 2003).

Forest fires may also have lagged effects, like reducing property values in adjacent residential areas or other areas with similar characteristics (Loomis 2004). To our knowledge, there are only a few studies on this subject (Loomis 2004; Napoleone and Jappiot 2008; Mueller et al. 2007) and no general conclusions can be made. The paucity of studies precludes making general conclusions, however the scant evidence points to a statistical significant reduction in housing price following a wildfire.

#### 3.2.1.2 Valuation of Goods and Services

Once all the relevant goods and services that have been damaged are identified and quantified (in physical terms), their social economic value and the total impact on the social welfare need to be estimated.

One of the challenges related to fire damage assessment is the existence of non-market goods and services. When considering forest goods and services, we can observe that only a part them, such as timber, are traded in markets and their value can be directly observed (market prices). On the contrary, other goods and services (e.g., biodiversity, recreation, soil protection) are provided to the community or to individual consumers either free of charge or at a symbolic fee which is well below production costs (OECD 2000). Nevertheless, these goods and services positively contribute to people's welfare and often represent a significant part of the fire induced losses. Thus, they cannot be omitted from the assessment of the economic impact of forest fires.

To clarify the difference between market and non-market goods and services, it has to be understood that in a free market economy goods and services are sold for prices that reflect a balance between the costs of production and what people are willing to pay, and can be considered as a proxy for the value of these goods and services. In turn, non-market good and service are neither bought nor sold directly, and do not have an observable monetary value. Hence, to estimate their value we need to apply other methods, which have been developed in the frame of economic valuation.

Economic valuation of non-market goods and services relies on the notion of *willingness to pay (WTP).* Willingness to pay for a particular good is defined as the maximum amount of other goods (e.g. money) an individual is willing to give up in order to having that good. WTP is determined by motivations which can vary considerably, ranging from personal interest, altruism, concern for future generations, environmental stewardship, etc. The economic value of the good to an individual is reflected in the willingness to pay of the individual for that good.

Hence, economic valuation methods provide us with approaches that attempt to elicit the monetary value that a certain change in the quantity and/or quality of non-market goods and services has for a society. These methods can be divided into two main groups: Revealed Preference[7] (RP) and Stated Preference[8] (SP) methods. These are based on the fundamental principles of welfare economics; whereby the changes in the well-being of individuals are reflected in their willingness to pay or willingness to accept compensation for changes in the provision or use of those goods and services (Hanley et al. 2001).

The RP methods (e.g., Market Prices, Hedonic Pricing, Travel Cost Method) are based on actual observed behaviour data, including some techniques that deduce

[7] More on revealed preference methods in Bockstael and McConnell (2007).

[8] More on stated preference methods in Kanninen, B. J. (Ed.) (2007).

values indirectly from behaviour in surrogate markets, which are assumed to have a direct relationship with the ecosystem service of interest. The SP methods (e.g., Contingent Valuation Method, Choice Modelling) are based on stated choices rather than people's behaviour on real markets; for the former the value is inferred from people's responses to questions describing hypothetical markets where they state their willingness to pay for an environmental good or service.

Related to fire damage assessment, the reconstruction cost approach, and the almost equivalent replacement and reproduction costs approaches, are the most common and robust methodologies. The methodology is based on the idea that the cost of replacing the goods and services provided by an environmental resource can offer an estimate of the value for that resource. This is based on the supposition that, if people incur costs to restore the services of ecosystems, then those services must be worth at least what people paid to replace them. The main underlying assumptions for this approach refer to the predictability of the extent and nature of the physical expected damage (e.g., there is an accurate damage function available). Besides, the costs to replace or restore damaged assets can be estimated within a reasonable degree of accuracy. It is assumed that the replacement or restoration costs do not exceed the economic value of the asset. The latter assumption, however, may not be valid in all cases. The value of the service may fall short of the replacement of restoration costs; either because there are few users or because their use of the service is in low-value activities. On the other hand, this approach may lead to an underestimation of the total economic value of a natural resource, because it considers only financial costs, but it does not account for non-market and non-use values of the valued asset.

The choice of a valuation method depends on the nature and the type of change in the goods or service we want to value. In general, measures based on observed behaviour are preferred to those based on hypothetical behaviour. However, the choice of a valuation technique in any given instance is dictated by the objectives and characteristics of the case and data availability

Although in theory it is recognized that non-market goods and services represent an important part of the fire induced losses, in practice they are very seldom included in the damage assessment approaches, as it will be shown in the next section.

## Current Status of Fire Damage Valuation in Europe: Differences Among Countries and Regions

This section is based on the information collected in a survey conducted in twelve European countries in the frame of the COST Action FP0701. The aim of the survey was to collect information about the methodologies applied for the estimation of economic damages caused by forest fires. Hence, the questionnaire contained questions about the existence of a methodology for the estimation of economic damages and its scope (e.g. national, regional).

The methodology was described in terms of goods and services that are considered when estimating fire induced damages and the methods (e.g., market price, economic

valuation, replacement costs, benefit transfer, and expert estimation) that are used for estimating the economic values of the damages. Furthermore, questions about estimation time frame (i.e. short or long) and application situations (e.g. compulsory to all fires, optional) were included.

Table 3.1 summarizes the results of the questionnaire, and shows that only a small number of the potentially affected goods and services are valued.

Wood and soil protection are the most frequently valued goods in the surveyed countries. Wood losses are mainly valued through market prices, while soil protection losses are estimated through expert consultation and replacement costs. Infrastructures, homes and other properties are also frequently valued. Probably this is related with the need for replacing those damaged assets and obtaining funds from insurance companies. Furthermore, in the damage assessment many countries also include suppression costs related to fire events. On the contrary, biodiversity and carbon sequestration are included into the damage assessment only in Italy. While biodiversity is valued through replacement cost calculations, carbon sequestration related losses are estimated by market prices (e.g., carbon credit prices). Also, fodder and forage losses are considered only in one country (Spain), where the value of the losses is based on expert estimations.

According to the results of the survey, Italy appears to be the country performing the most complete assessment (e.g., see the methodology proposed by Ciancio et al. 2007). Most surveyed countries have developed damage assessment protocols that are compulsory for all fires. Those protocols are usually applied by forest management departments. However, there are also exceptions, like in the French case, where insurance companies are responsible for the application.

On the other hand, some countries (e.g., Switzerland and Greece) lack standard assessment procedures. In Switzerland, estimations are conducted only where the cause for fire ignition is known; while in Greece after important fire events ad-hoc expert committees are established to estimate the damages, but no systematic protocol is implemented despite the high frequency of fires.

Most countries conduct short term damage evaluations, generally immediately after the fire event, while no assessment of fire impact is done in the long/medium term.

To summarize, from the inputs obtained from the surveyed countries we can conclude that there is room for significant improvement in the assessment of fire damage across Europe. A more complete valuation would consider items that nowadays are rarely tackled (e.g. water, recreation, health impacts) and would take into account medium term effects of fires. These would be desirable goals towards a more complete valuation of fire damages.

#### 3.2.1.3 Recovery Patterns and Periods of Goods and Services

The reduced flow of goods and services after a fire can be permanent or temporary. In most cases the recovery pattern and time needed to restore the provision (flow) of

**Table 3.1** European countries surveyed and assets valued by them in forest fire damage assessment

| Countries/assets valued | Bulgaria | Cyprus | Greece | France | Italy | Lithuania | Portland | Portugal | Romania | Spain | Switzerland | Turkey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Forest goods and services* | | | | | | | | | | | | |
| Industrial wood | x | x | | x | x | x | x | | x | x | x | x |
| Fuel wood | x | x | | x | x | x | | | x | x | x | x |
| Cork | | | | | x | | | | | x | | |
| Food | | | | | x | | | | | x | | |
| Fodder and forage | | | | | | | | | | x | | |
| Decorative material | | | | | | | | | | | | |
| Hunting and game products | | | | | x | | | | | | | |
| Pharmaceuticals | | | | | | | | | | | | |
| Biodiversity protection | | | | | x | | | | | | | |
| Climate regulation | | | | | | | | | | | | |
| Air quality regulation | | | | | | | | | | | | |
| Carbon sequestration | | | | | x | | | | | | | |
| Health protection | | | | | | | | | | | | |
| Water regulation | | | | | x | | | | | | | |
| Water purification | | | | | | | | | | | | |
| Soil protection | | | | x | x | | | | x | x | x | |
| Recreation | | | | | x | x | | | | | | |
| Sports | | | | | x | | | | | | | |
| Tourism | | | | | x | | | | | | | |
| Spiritual and cultural services | | | | | | | | | | | | |
| Historical and educational services | | | | | | | | | | | | |
| Aesthetic services | | | | | | | | | | x | | |
| *Other goods and services* | | | | | | | | | | | | |
| Infrastructure | x | | | x | x | x | x | | x | | | x |
| Homes | | | | x | x | x | x | | x | | | x |

(continued)

**Table 3.1** (continued)

| Countries/assets valued | Bulgaria | Cyprus | Greece | France | Italy | Lithuania | Portland | Portugal | Romania | Spain | Switzerland | Turkey |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Other property | x | | | x | x | x | x | | x | | | x |
| Agriculture and similar products | | | | | x | x | x | | x | | | x |
| Losses to business | | | | | | x | | | | | | x |
| Health impacts | x | | | | | | | | | | | x |
| *Suppression costs* | | | | | | | | | | | | |
| Material costs | x | x | | | x | x | | | | x | x | x |
| Personnel costs | x | x | | | x | x | | | | x | x | x |

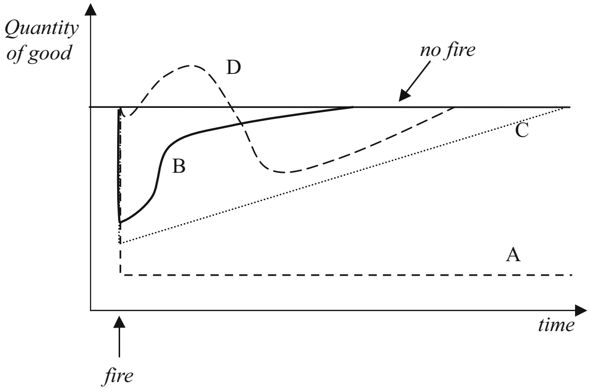


**Fig. 3.4** Valuation of damage costs with an approach based on the missed flow of products and services

goods and services will be case specific, and dependent on different factors, like fire size and severity (Mercer et al. 2007), type of damaged goods, and management measures taken.

Very little is known about the post-fire recovery patterns, because of their heterogeneity. In fact, recovery patterns may have different forms for different goods and services (Fig. 3.4):

- some goods and services may never be recovered (e.g. species going extinct or a monumental tree destroyed by the forest fire – Curve A);
- some goods and services may be recovered very quickly (e.g. water absorption and erosion control in a forest area with no problems of revegetation – Curve B);
- other may recover only in the long term, like recreation in a formally old-growth forest (Curve C);
- some goods and services may even increase after the fire events (Curve D) with respect to the "without scenario" (e.g. herbs production).

Moreover, the function representing the recovery path may be linear (C) or may, more probably, take some other non-linear form (B and D). We should also consider that in most cases various goods will be damaged simultaneously and that their recovery processes could be interrelated.

The estimation of the recovery period and the impact of post-fire management measures on the recovery of the flow of forest goods and services represent another challenge in the process of economic evaluation of post-fire management measures. Although theoretical approaches recognize the role of time in calculating the loss of different forest goods and services, in practice such aspect is not always considered. This is because in most cases, specific studies about post-fire forest recovery dynamics do not exist for the site or forest ecosystem affected by the fire. Furthermore, forest functions are so interconnected that it is difficult to define specific time span

for each of them, and some fire damages (soil erosion, debris flow, water pollution, local tax revenues, etc.) do not reach the maximum intensity immediately after the fire, but a certain time later.

Nevertheless, in the literature some suggestions can be found about potential recovery periods for different forest goods and services, even though they should not be generalized and will most likely differ significantly from case to case. For example, Molina et al. (2009) report that in their cases NWFP yields were affected on average over a 4 year period, although the production decrease was not constant. There are a number of studies dealing with the impacts of fire on recreation; however, they differ considerably in their conclusions on how recreation use changes immediately after a forest fire or during the restoration period (Loomis et al. 1999). For example, Flowers et al. (1985) reported that the effects of fire on recreation (number of visitors) can persist from 6 months to 7 years. On the other hand, Loomis et al. (2001) estimated that the effect of forest fires (depending on the type of fire, crown or surface fire) on hiking trips could persist over a very long period (up to 50 years). Another complex issue is the effect of fire on ecosystem biodiversity and the number of years needed to recover to pre-fire levels can vary significantly. Based on experience from two fires in Andalusia, Molina et al. (2009) reported that after a fire, the habitat conditions are re-established somewhere between 2 and 12 years, depending on the fire severity and vegetation composition.

#### 3.2.1.4 Impacts of Post-Fire Management on the Flow of Goods and Services

Little is known about the recovery processes of the flow of goods and services, but there is even less information about the impacts of post-fire management measures on this process.

In general we assume that post-fire management measures should accelerate the recovery process and/or reduce potential further losses of goods and services (Fig. 3.1). For example, initially the reduced vegetation cover after a fire does not provoke increased soil erosion, which normally appears after the first heavier precipitation. Thus post-fire measures (e.g., soil stabilization measures) could prevent the loss of soils. This example is also illustrated in Fig. 3.1, where we see that by applying post-fire management measures (line C) the loss of the good is considerably smaller ($Q_1'$) and the recovery process is shorter ($t_2'$), compared to the situation where no such measures were applied (line B).

Thus, to assess the impact on the social welfare of post-fire management we have to know its impact on the flow of goods and services (market and non-market), and the economic value of these changes.

However, as Vega et al. (2008) points out, there is still a lack of knowledge, regarding post-fire management and restoration measures. For example, whether and when burned trees should be removed or not, which logging techniques to be used, the type of management of logging residues and the effects of interaction between fire severity and harvesting. Nevertheless, there are some studies that deal with effects of different post-fire management measures. A few examples are given below.

González-Ochoa et al. (2004) examined the effects of different post-fire silvicultural treatments on tree growth in Aleppo pine (*Pinus halepensis*) forests. They found that tree growth is improved by applying thinning on a good quality site, and thinning and scrubbing on worse quality sites. Furthermore, thinning and scrubbing improved the probability of cone production, which will guarantee the regeneration capacity of the forest. Izhaki and Adar (1997) conducted a study on Mt. Carmel, in Israel and found that different post-fire management measures increased the number of bird species. Furthermore, Spanos et al. (2007) examined the effects of fire and different logging (animals and mechanized) procedures on soil characteristics and loss. They found that fire and logging did not affect the soil pH and caused only a short-term reduction of organic matter content. Logging and particularly the use of skidders for log removal caused an initial increase in the amount of exposed bare ground but later when vegetation cover increased differences were minimized. Two years after the fire, the highest rates of soil loss were observed in the logged area where mules were used for log removal. Soil moisture showed some differences between treatments during the first year after fire but then values were similar. The main woody species showed a species specific response to the treatments and while seeder species were favored in the unlogged sites the same was not true for the re-sprouters. In general, the growth and survival of pine seedlings was not affected by treatments.

González-Ochoa and de las Heras 2002 studied pest outbreaks in restored Aleppo pine (*Pinus halepensis*) stands and the influence of post-fire practices. Due to high densities reached by this species after fire, thinning is necessary. However, they found silvicultural practices could be a trigger for an outbreak of defoliator species (e.g., *Polyporus squamosus*).

When addressing post-fire practices, erosion and fire risk should be considered simultaneously. Marques and Mora (1998) compare soil erosion of clear-cutting and immediate removal of burned trees versus the non-interventions. Although they did not find evidence that clear-cutting increases post-fire erosion, they observed that roads constructed for logging activities accounted for an important part of the erosion in the area. On the other hand, they highlight that left trees could increment the fire risk.

Finally, Vega et al. (2008) evaluated regeneration of Maritime pine (*Pinus pinaster*) stands in Galicia under different post-fire management options. Although harvesting and slash logging resulted in significantly higher seedling mortality, they did not influence the restoration potential of the stands. At the same time they remarked that excessive seedling density may result in a significant increase in the cost of pre-commercial thinning in these stands.

#### 3.2.1.5 Costs of Post-Fire Management

Finally, to complete the information needed tor the evaluation of efficiency of post-fire management alternatives, we have to know the costs of the implementation for each of them. Here we have to consider all the resources used (e.g., labor, raw

materials, equipment) and their costs. It should be acknowledged that we should consider all the costs that appear over the whole restoration period and not only the costs immediately after the fire.

The post-fire management costs should in most cases be relatively easy to predict, because in most countries standardized costs and norms for restoration measures are available. A detailed example of post-fire management measures and their costs for Catalonia is given in Mavsar et al. (2009).

#### 3.2.1.6 Efficiency Evaluation of Post-Fire Management

Once all the necessary information is collected we estimate for each post-fire management alternative the net impact on social welfare. For each alternative (including the no management option) we estimate the social net present value. This is done by discounting all costs and benefits to the initial year (e.g., immediately after the fire), and subtracting costs from benefits. After estimating this for all alternatives we evaluate which of them would have the highest positive impact on the social welfare[9] and would thus be the most efficient from the social perspective.

### *3.2.2 Distributional Effects of Post-Fire Management*

The economic efficiency criteria presented in the previous section does not consider distributional effects (equity) of post-fire management investments. From a social perspective it does make a difference who profits from the generated benefits or the avoided costs of a post-fire investment (Riera et al. 2005). This is in particular important, because there is evidence that natural disasters, such as forest fires, impact to a greater extent on the poorer parts of the population than the wealthier (Holmes et al. 2007).

Therefore, when evaluating post-fire management measures also the distributional effects should be considered. In this line different aspects of post-fire management could be evaluated. For example, whether new jobs are created and who benefits from this, how the costs and benefits of the investments are distributed in the society, whether the investment helps to alleviate poverty or decrease income distribution in the affected area, whether it affects established land use patterns or land tenure agreements, etc.

There is a wide range of economic effects of a post-fire management investment that can be evaluated. However, which of them will actually be considered in the evaluation process mainly depends on the characteristics of the investment (e.g., size, type, economic and social effects) and the socio-economic characteristics

[9] Actually a number of indicators exist (e.g., benefit-cost ratio, internal rate of return) that are complementary to the net present value and that would be considered when conducting a CBA.

of the affected area. This part of the economic evaluation of post-fire management is closely related to the social aspects that will be described in more detail in Sect. 3.3.2. This only underlines the importance of a balanced consideration of different aspects (ecological, economic and social) when taking decisions about post-fire management.

## 3.3 Legal and Social Aspects of Post-Fire Management

The intensity and scale of fire-related problems is highly variable in Europe; thus, it is not surprising that social and legal frameworks on wildfires are influenced by the perceived level of threat (Montiel and Herrero 2010). In the light of this, the main goal of this section is to highlight and examine such frameworks with distinctive reference to post-fire management and related decisions.

### *3.3.1 Legal Issues*

A review is presented based on a sample of 18 countries from different regions of Europe and of the Mediterranean basin, that include (one or more) ad hoc post-fire management provisions in national legal frameworks. Information has been collected through specific questionnaires in the framework of the FP0701 Cost Action (see the list of responding countries on Table 3.2) and by reviewing the sparse literature on the subject (FAO, 2007; Rosenbaum, 2007).

Key legislation, programs and regulations encompassing post-fire management are compared among selected countries, with the main goal to get a sense of technical issues currently addressed by national legislation.

Post-fire management issues are considered within laws dealing specifically with forest fires, or by more comprehensive texts addressing forest fire management together with other forest management aspects. In some countries the legal framework on forest fires can be very fragmented and scattered across laws and regulations regarding forests, protected areas, hunting, local governance, civil defense, environmental protection, agricultural land protection, land use and internal affairs (Morgera and Cirelli 2009). Legal provisions regulating post-fire management in fire-affected areas are generally not different between public and private land. Obligations and responsibilities for the implementation of legal provisions are usually allocated to land owners, most frequently private (Fig. 3.5).

Key post-fire management issues considered by the national legal frameworks are (Table 3.2):

1. the interdiction of land use conversion in forest burned areas;
2. the post-fire harvesting and measures to prevent soil erosion;
3. the post-fire forest regeneration: both active forest restoration (planting and seeding) and passive restoration (management of natural regeneration) approaches are foreseen by the law.

**Table 3.2** Key legal provisions applied to forest burned areas in selected European countries

| Country | Interdiction of land use conversion | Post-fire harvesting (salvage logging or management of burned trees/wood) | Soil erosion mitigation and flood prevention | Forest regeneration by planting or seeding | Management of natural regeneration | Grazing/browsing control |
|---|---|---|---|---|---|---|
| Bulgaria | x | | | x | | x |
| Cyprus | | | | x | | |
| Estonia | | | | x | | |
| France | x | x | x | x | | |
| Greece | x | x | x | x | | x |
| Israel | | | | | | x |
| Italy | x | x | | x | | x |
| Latvia | | | | x | x | x |
| Lithuania | x | x | | x | x | x |
| Morocco | x | | x | | | x |
| Poland | x | | | x | x | x |
| Portugal | x[a] | x | x | x | | x |
| Romania | x | x | x | x | x | |
| Spain | x | x | x | | x | x |
| Slovenia | | | | x | | |
| Switzerland (Ticino) | x | | | | | |
| Tunisia | | | | | | x |
| Turkey | x | | | | | |

[a]For selected forest types (e.g. cork oak forest)

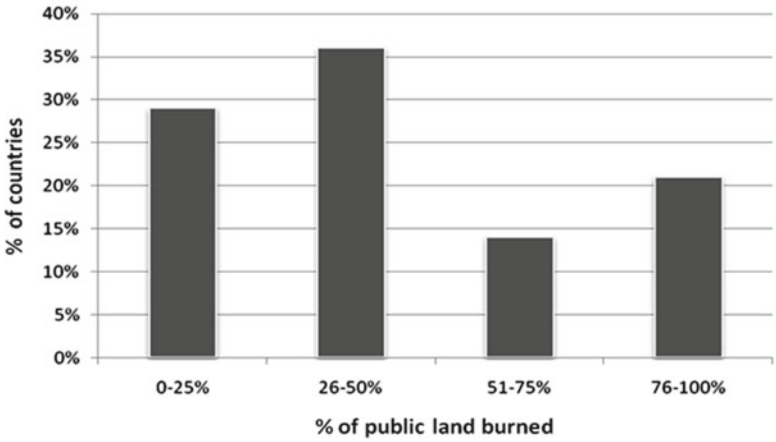


**Fig. 3.5** Split of countries considered in the review by rate of public land burned

#### 3.3.1.1 Land Use Conversion

Land use conversion in forest burned areas is explicitly prohibited by law in most countries. There is a general consensus on the illegality of post-fire land use conversion, although with significant differences between countries e.g. in the length of time for non-conversion. The law generally prohibits: (i) the conversion of forest burned areas in urban land uses (e.g. housing, industrial or tourism); (ii) changes to terrain morphology or plant cover of the site for a certain period of time after fire occurrence.

Some examples of the legal provisions are:

- Bulgaria: the national Forest Law forbids the converting of burned forest area to any different land use for a period of 20 years (Bulgaria's Forest Law, Prom. SG. 125/29 Dec 1997, amend. SG 16/03, Art. 14);
- Lithuania: in special cases burned forest areas might be turned into open landscapes, e.g. in protected areas where aesthetical values are of high priority and further used for recreational purposes;
- Poland: the land use conversion of forest areas, whether burned or not, requires a special administrative decision;
- Italy: the national framework law on forest fires (no. 353/2000) forbids land use change in burned areas; in particular it is strictly forbidden: for 15 years after fire to change land-use, for 10 years to establish building or infrastructures, to hunt and graze, for 5 years to reforest using public funds. Land use changes are monitored by the Cadastre of burned areas. Despite this, illegal transformations occur. A similar situation is observed in Greece, despite the law which declares burned areas as afforested areas subject to strict protection measures (Table 3.2).

**Table 3.3** Example of measures to prevent grazing/browsing on forest burned areas

| Country | Fences | Repellent for wildlife control | Tree shelter | Hunting |
|---|---|---|---|---|
| Bulgaria | x | x | | |
| Italy | x | x | x | |
| Latvia | | | x | |
| Lithuania | | x | | |
| Poland | x | x | | |
| Portugal | x | | x | x |
| Romania | x | | | |
| Spain | | | x | |

#### 3.3.1.2 Post-Fire Harvesting and Other Protection Measures

Other restrictions applied to forest burned areas mainly concern harvesting of damaged trees (salvage logging) and measures to protect soil and natural regeneration. Italian legislation foresees, as a general measure, early post harvesting, in general in the first months after fire. Post-fire harvesting criteria are defined by laws also in Bulgaria, Romania and Portugal. Provisions to mitigate post-fire soil erosion in forest burned areas and prevent flood risk are also found in some countries. Under undisturbed conditions forest natural regeneration is common after fire, especially in Mediterranean forests types where many plant species are adapted to fire disturbance. Grazing represents often the main disturbance for regeneration establishment: therefore, interdiction of grazing/browsing is a common measure in the examined legislation. Many national legislations apply grazing restrictions for 5 years after fire; several instruments can be implemented to prevent wild/domestic animals disturbance (Table 3.3). Legislation can also prevent the illegal use of fire to clear grazing areas in forests, by prohibiting grazing of livestock on any land that has been subject to wildfires for a period of 10–20 years (Bourrinet 1992).

#### 3.3.1.3 Forest Restoration Measures

Another key issue addressed by the legal instruments is to ensure the forest restoration in fire-affected areas when natural processes are not expected to provide adequate regeneration. On this issue the law generally states rights and obligations and the basic objectives and principles to be implemented: e.g. the use of native species for forest restoration is required in most countries (France, Italy, Portugal, Romania, Spain, Switzerland, Turkey, Greece, Poland, Albania and Tunisia).

Forest restoration funding is generally supplied by specific funds allocated at national or regional level e.g. by the Rural Development Plans under the European common agricultural policy framework. Some countries report the lack of funding as one of the main constraints to effective implementation of forest restoration action.

In some cases, the legislation spells out specific obligations, e.g. the preparation of a rehabilitation plan after extensive fires or to ensure consistency between various rehabilitation operations including restoration of the uses of the area and prevention of new fires (Morgera and Cirelli 2009). Examples of legal provisions to ensure the forest restoration process are:

- Switzerland (Canton Ticino): in case of dangerous events, the Municipality, after the authorization of the State Council, can promptly decide the most appropriate measures for protection and rehabilitation; all actions and measures should be taken in the highest respect of the environment; in case of a lack in the involvement of the Municipality, the State Council officially intervenes;
- Slovenia: the Slovenian Forestry Institute, established to perform public forestry services in all forests, monitors the extent and the level of degradation and damage of forests and reports on this to the competent Ministry, which shall order measures for removing the causes of the degradation or damage to forests.

Legislation may also allocate responsibilities for rehabilitation when fire affected lands are included in protected areas. This is the case of Portugal's Decree-Law 139/88: if burned private forests are located in protected areas, the owner could be called upon to produce a replanting plan to be approved by the protected area authority and, for areas larger than 100 ha, an environmental impact study can be also required.

Legislation may also create specific tree-planting obligations to ensure rehabilitation of forest areas after a fire. In Portugal and Bulgaria, the owner of burned forests is obliged to replant trees within 2 years following a fire (Portugal's Decree-Law No. 139/88; Bulgaria's Forest Law, Prom. SG. 125/29 Dec 1997, amend. SG 16/03, Art.42) and within 5 years in Poland. In Spain regional laws foresee the private landowner reforesting forest burned areas when natural regeneration is not expected in the mid-term.

In Cyprus for the State forest there are no legal constraints regarding restoration; however, all State forest burned areas are usually reforested after fire. In the same way, also for the private forests there are no legal provisions regulating this matter. The final and determinative decision for the future of private forest burned areas is left to land owners of fire-affected areas.

A different approach is taken in Italy by the national framework law on forest fires (Law no. 353/2000). Post-fire afforestation and any public-funded action of environmental engineering are forbidden in burned areas for 5 years after fire, unless specific authorization is released from the Regional Administrations or the Ministry of Environment. This is meant to prevent speculation, as investing too much in restoration activities might stimulate further fires in areas having problems of unemployment. Furthermore, the national legislation forces the Municipalities to establish the so-called "Cadastre of burned areas" with the support of the State Forest Service. The Cadastre of burned areas considers a burned area always a consequence of an illegal act and any intervention is forbidden for the following period of 5–15 years.

Technical specifications for the implementation of forest restoration measures are generally left to subsidiary legislation; possibly, subsidiary legislation could

expressly prohibit the substitution of certain species with others for certain environmental purposes (Bourrinet 1992). Relevant examples are:

- Lithuania: burned areas have to be reforested by sowing or planting tree species suitable for the site. Administrations of forest enterprises and national parks provide information on available seedlings to help local forest owners to find suitable planting material; generally any change in species composition is not allowed: according to Forest Law, damaged pine stands should be restored by new pine stands; mixture of pine with deciduous tree species (e.g. birch) is allowed only to create fire barriers (Forest Law, 2001-04-10, Nr. IX-240, Regulations on protection of forest from fires, Document Nr. 500);
- Estonia: a forest may be reforested only with tree species suitable for the forest site type and the Minister of Environment shall establish the list of the types by the rules of forest management. The forest owner is required to apply reforestation methods in damaged parts of forest with an area of at least 0.5 ha within 2 years after the damage.

#### 3.3.1.4 Legal Outline Remarks

As countries from different European and Mediterranean regions are covered in the sample, legal approaches here presented can be regarded as being sufficiently comprehensive to outline general key findings on national legislation concerning post-fire management.

(i) Legislation appears to be useful as a framework enabling forest owners and responsible authorities to identify necessary action to be taken in fire affected areas. Interdiction of land use conversion, forest restoration and grazing control appear to be common cross-cutting issues across regions.

(ii) Countries of the Northern Mediterranean basin (Spain, Portugal, France, Italy, and Greece) have the most well-constructed legal provisions, touching several issues of post-fire management (Table 3.2); in this regard, other Mediterranean countries facing similar fire conditions might benefit from these examples, when formulating or revising national legislation on fire management.

(iii) Despite the existence of a legal framework on post-fire management, the implementation of the law is acknowledged as a key problem. Especially in some Mediterranean countries legal provisions are not effectively enforced at the field level and the reality is sometime a “deviation” from the legislation. Current (and foreseeable) law enforcement capacities should be therefore taken into account when preparing relevant provisions. Important issues related to law enforcement include also:

    - financial instruments supporting the implementation of legal provisions; taking into account that most of the fire affected forest areas in Europe are privately owned, obligations like tree planting provisions for forest restoration are unlikely to be implemented by small-scale owners unless funding is available;

- ensuring compensation for damage caused by forest fires. This calls for sound methodologies to assess the economic impacts of forest fires (see Sect. 3.2).

### 3.3.2 Social Issues

Four vectors interact to determine the social experience of the post-fire management: (i) the extent and characteristics of the fire; (ii) the history of relations between the fire management agency/forest services and the local community; (iii) economic implications of the fire; (iv) the level and consistency of the agency/service communication (Ryan and Hamin 2006). After wildfire, fire management agencies and forest services often undertake forest restoration efforts taking, generally, only a technical perspective. Limited efforts are usually made to take explicitly into account the public's perceptions, both aesthetically and ecologically, to fire recovery treatments, as well as the involvement of the community in post-fire planning. On the other hand, appropriate forest treatments can only be determined in light of the management objectives for that particular area of the forest, and those objectives are determined in part by the local community's needs, desires, and aesthetic preferences. The difficulty lies in what can be thought of as the distributional effects of restoration: the community as a whole may benefit but the direct and indirect costs of carrying out restoration may be paid by a much smaller number of individuals such as those owning or using the land that is treated (Lamb 2009).

The ability to intervene and undertake restoration in the various land units will depend on who owns or uses the land and how these people fit into the various landowner or land user classes; of course, implementing restoration actions will be easier in the case of public (e.g. Turkey) or prevalently public burned forest land.

But, in addition to these on-site land managers there may also be other stakeholders (e.g. tourists) with legitimate interests in the way these lands are managed (Lamb 2009). Some of the factors that may influence the attractiveness of restoration to landowners are shown in Table 3.4 (see also Sect. 3.2.2).

Rather complex arrangements might be needed where restoration is undertaken as a community activity rather than by individuals. Unlike the situation involving individual farmers, the opportunity costs in this case are mostly low. However, as highlighted by a survey carried out within the framework of the FP0701 COST Action, the direct involvement of local communities in post-fire recovery activities is generally quite unusual in Southern Europe, and it mostly concerns replanting. Where communities are heavily involved in the forest rehabilitation, the efforts have a very positive effect on perceptions of the post-fire recovery, as well as helping to re-build the community spirit eventually hampered by the wildfire event. Ryan and Hamin (2006) describe how different restoration efforts compare to natural revegetation from the public's perspective, and how to effectively communicate with and engage the public in the rehabilitation process. Overall, resident perceptions are reported to be better after the fire than before, and acceptance of hazard mitigation

**Table 3.4** Socio-economic factors that may influence the attractiveness of restoration to farmers and landowners (from Lamb 2009)

| Factor | Significance |
|---|---|
| Land tenure | Farmers without secure land tenure or usufruct rights are unlikely to undertake a land use activity such as restoration where the benefits take time to achieve |
| Availability of agricultural land | The commercial viability of a farm will often depend on its size; it may be easier to undertake ecological restoration on a large farm than on a small farm because the initial impact of the change is proportionally smaller |
| Productivity of land | Restoration will be more attractive on land that is regarded as unproductive (because of lost soil fertility, weeds, pests etc. ) than on land that is still highly productive; this is because the opportunity costs incurred in converting productive land would be too high |
| The likelihood of financial or other direct benefits arising from restoration | Landowners are more likely to be interested in a land use activity that benefits them immediately and directly; benefits may come from goods such as timber or services such as improved water supplies or new wildlife habitats |
| Availability of subsidies, incentive payments or tax concessions | Such payments may be especially significant for small, risk-averse landowners or those with low incomes |
| Legal obligations to overcome degradation | There may be legal requirements on landowners to prevent fires or eradicate weeds or pests |
| Availability of alternative sources of off-farm income | Landowners able to obtain income from off-farm employment may be more able to convert part of their land holdings to new uses such as restoration |
| Attitude of neighbours | Neighbors can have positive and negative influences; innovative neighbors can provide examples to be copied but conservative neighbors can also argue against change and diminish the propensity of innovators to take on risky new land uses |

measures increases significantly. A second important aspect might be supporting volunteers in rehabilitation efforts, which both aids the forest and helps the community heal from the trauma of the fire. However, only in a few European countries are volunteers directly engaged in restoration activities, whilst they are much more involved in surveillance and fire fighting.

#### 3.3.2.1 Post-Fire Management Practices and Their Social Success

Most people view the question of best restoration and rehabilitation treatments as a question for science and forest service expertise. However, on some items the public have usually clear opinions. A wide majority of stakeholders support salvage logging after wildfire, even in communities where salvage logging did not occur. One point of near consensus is the need to remove hazard trees from trails and to re-open

**Table 3.5** Socio-economic indicators of the success of restoration activities (from Lamb 2009)

| Indicator | Reason |
|---|---|
| Incomes of resident households improving | Farmers with declining incomes are unlikely to be able to afford to implement or maintain restoration activities |
| Payments being made for ecological services | External stakeholders willing to pay land managers for on-site restoration activities that yield ecological services such as clean water, biodiversity or wildlife habitats |
| Individual landowners continuing to protect and maintain restored sites. spontaneous restoration at other sites by individual landowners without the need for external subsidies or support | Landowners continue to view restoration on their land as being a valid and beneficial land use; the benefits of restoration are self-evident to individual landowners resulting in increased areas of degraded land being treated; the more of such new sites the greater the "success"; a corollary of this is that no new areas of degradation are evident |
| Development of private enterprises able to carry out or benefit from restoration activities (e.g. seedling nurseries, reforestation companies, weed control companies, ecotourism groups etc.) | Restoration and the land uses it fosters have become commercially profitable and created employment and new economic opportunities |
| Development of institutions and learning networks amongst landowners aimed at fostering rehabilitation | These institutions and networks generate, accumulate and transfer knowledge about restoration and the ways it can be incorporated in local land use systems |
| Validation and community support for policies, regulations and institutions designed to protect restored areas and prevent future degradation | These regulations may be formal government legal regulations, traditional community regulations or new rules established by communities to facilitate the management of newly acquired common property resources; the institutions may be traditional community organizations or government regulatory bodies |

trails and other popular recreation areas as quickly as possible. Another point is that forest stand thinning usually gains much popularity after the fire. Overall, there is general support for forest restoration near the urban interface but much less so in the backcountry. Distinctively, people usually strongly support rehabilitation techniques that stabilize soils and minimize flood damage near developed areas (Ryan and Hamin 2007).

It is a rather difficult task to assess the socioeconomic success of restoration. There may be a large number of stakeholders who may react quite differently to a restoration or rehabilitation project with some judging it a success and others counting it a failure. Perhaps the key indicator is that institutions and learning networks have evolved enabling different experiences to be integrated, synthesized and shared amongst practitioners (Table 3.5).

Such learning networks will assist these communities to withstand future ecological or economic shocks and prevent further degradation (Lamb 2009).

#### 3.3.2.2 Social Outline Remarks

Few Southern European countries have mechanisms in place to educate in the area of post-fire management. On the other hand, the survey carried out in the framework of the FP0701 Cost Action indicates that where there are understanding and awareness of the role of fire and its impacts, the average size of the burned area is diminishing and there is more reporting of fires along with more public interest in rehabilitation of fire burned areas.

It is widely acknowledged that the local communities should be involved in the recovery processes. It is on how to do this where thoughts differ and the lack of clear strategies in many cases which hinder greater participation. There is an obvious need for more awareness raising and planning for integration of communities into the long term planning by fire management agencies and forest services so that there is some ownership of the plans and a feeling of ownership of what happens to and in the forests: the end result would then be that the public shares responsibility for the ongoing preservation of the forests. This argues for fire management agencies and forest services to consider explicitly the social communities when planning post-fire restoration projects. Distinctively, understanding the public's likely response to rehabilitation efforts has several benefits for improving management, and the crucial post-fire period provides a window for significantly improving community/agency relations. The key to successful post-fire rehabilitation from the local community's perspective is for managers to quickly communicate the rehabilitation planning and continue to communicate longer-term restoration efforts to the community.

## 3.4 Key Messages

- To select the optimal post-fire management and restoration measures, the corresponding decisions should be based on environmental, economic and social aspects.
- The economic aspects should contribute to estimate the economic efficiency and distributional (equity) effects of the post-fire management measures. The economic efficiency measures the impacts of the post-fire management measures on societies welfare, while the distributional effects indicate who wins and who loses if a certain type of post-fire management measures are implemented.
- Currently only a fraction of economic effects of fires are considered in European countries. There is no commonly agreed approach how to estimate the economic effects of fires and what aspects should be included. This situation considerably limits the possibilities of decision makers to select optimal post-fire and restoration measures.
- It is recommended that efforts are made at the pan-European level to implement procedures that would enable a sound estimation of economic effects of fires. These procedures would enable on one hand the accurate estimation of economic

losses, and on the other hand more objective selection of post-fire management and restoration measures.

- Legislation appears to be useful as a framework enabling forest owners and responsible authorities to identify necessary action for post-fire management. Interdiction of land use conversion, forest restoration and grazing control appear to be common cross-cutting issues across countries of Southern Europe.
- Despite the existence of a legal framework on post-fire management, the implementation of the law is acknowledged as a key problem. Current (and foreseeable) law enforcement capacities should be therefore taken into account when preparing relevant provisions. Important issues related to law enforcement include financial instruments supporting the implementation of legal provisions and ensuring compensation for damage caused by forest fires.
- There is a need for more awareness raising and planning for integration of communities into the long term post-fire planning by fire management agencies and forest services: the crucial post-fire period provides a window for significantly improving community/agency relations.
- The key to successful post-fire rehabilitation from the local community's perspective is for managers to quickly communicate the rehabilitation planning and continue to communicate longer-term restoration efforts to the community.

## References

Abt KL, Huggett RJ, Holmes TP (2008) Designing economic impact assessments for USFS wildfire programmes. In: Holmes TP, Prestemon JP, Abt KL (eds) The Economics of Forest Disturbances: wildfires, storms, and invasive species. Springer, New York, pp 151–166

Arrow KJ, Hahn FH (1971) General competitive analysis. Holden-Day, San Francisco

Barrio M, Loureiro M, Chas ML (2007) Aproximación a las pérdidas económicas ocasionadas a corto plazo por los incendios forestales en Galicia en 2006. Econ Agraria y Recursos Nat 7:45–64

Beyers JL, Neary DG, Ryan KC, DeBano LF (2005) Wildland fire in ecosystems. Effects of fire on soil and water. United States Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Co

Bockstael NE, McConnell KE (2007) Environmental and Resource Valuation with Revealed Preferences. In: Bateman IJ (ed.) Springer. Dordrecht, The Netherlands

Bourrinet J (1992) Wildland fires and the law: legal aspects of forest fires worldwide. Nijhoff Publishers, Dordrecht

Brown JK, Smith JK, (2000) Wildland fire in ecosystems: effects of fire on flora, Gen. Tech. Rep. RMRS-GTR. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT (USA), p 257

Bulgaria's Forest Law, Prom. SG. 125/29 Dec 1997, amend. SG 16/03, Art. 14

Butry DT, Mercer DE, Prestemon JP, Pye JM, Holmes TP (2001) What is the price of catastrophic wildfire? J Forest 99:9–17

Ciancio O, Corona P, Marinelli M, Pettenella D (2007) Evaluation of forest fire damages in Italy. Accademia Italiana di Scienze Forestali, Firenze, p 60

Dickie M, Messman VL (2004) Parental altruism and the value of avoiding acute illness: Are kids worth more than parents? J Environ Econ Manag 48(3):1146–1174

EEA (2009) Greenhouse gas emission trends and projections in Europe 2009: tracking progress towards Kyoto targets. European Environmental Agency, Copenhagen, p 180
EFTEC i.c.w. Environmental Futures Limited (2006) Valuing our natural environment. Final Report. London
Englin J, Holmes TP, Lutz J (2008) Wildfire and the Economic Value of Wilderness Recreation. In: Holmes TP, Prestemon JP, Abt KL (eds.) The Economics of Forest Disturbances – Wildfires, Storms, and Invasive Species. Forestry Sciences, vol. 79, p. 191–208
EU (2005) Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). In: C.o.t.E. (ed.) Union, Offical Journal L 277, Brussels, pp 1–40
FAO (1999) Towards a harmonized definition of non-wood forest products. Unasylva 50 (1999/3)
FAO (2007) Fire management. Global assessment 2006. FAO, Rome
Farrell EP, Fuhrer E, Ryan D, Andersson F, Huttl R, Piussi P (2000) European forest ecosystems: building the future on the legacy of the past. For Ecol Manag 132:5–20
Flowers P, Vaux H, Gardner P, Mills TJ, (1985) Changes in recreation values after fire in the RockyMountains, Res. Note PSW. USDA Forest Service, Pacific Southwest Forest and Range ExperimentStation, Albany, CA, p 15
González JR, Kolehmainen O, Pukkala T (2007) Using expert knowledge to model forest stand vulnerability to fire. Comput Electron Agric 55:107–114
González-Cabán A (1998) Aspectos Económicos de la Evaluación del Danõ de Incendios. USDA Forest Service, Pacific Southwest Research Station
González-Cabán A (2007) Wildland fire management policy and fire management economic efficiency in the USDA Forest Service, Wildfire 2007-4th international wildland fire conference, Seville, Spain
González-Ochoa A, de las Heras J (2002) Effects of post-fire silviculture practices on Pachyrhinus squamosus defoliation levels and growth of Pinus halepensis Mill. For Ecol Manag 167:185–194
González-Ochoa AI, López-Serrano FR, de las Heras J (2004) Does post-fire forest management increase tree growth and cone production in Pinus halepensis? For Ecol Manag 188:235–247
Görlach B, Landgrebe-Trinkunaite R, Interwies E, Bouzit M, Darmendrail D, Rinaudo JD (2004) Assessing the economic impacts of soil degradation. Ecologic, Berlin
Hanley N, Spash CL (1993) Cost-benefit analysis and the environment. Edward Elgar Publishing Ltd., Cheltenham
Hanley N, Shogren JF, White B (2001) Introduction to environmental economics. Oxford University Press, Oxford
Hassan RM, Scholes RJ, Ash N, Millennium Ecosystem Assessment (Program). Condition and Trends Working Group (2005) Ecosystems and human well-being: current state and trends: findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment. Island Press, Washington, DC
Hicks JR (1939) The foundation of welfare economics. Econ J 49:696–712
Holmes TP, Abt KL, Huggett RJ, Prestemon JP (2007) Efficient and equitable design of wildfire mitigation programs. In: Daniel TC, Carroll MS, Moseley C, Raish C (eds) People, fire and forests. Oregon State University, Corvallis, pp 143–156
Holmes TP, Prestemon JP, Abt KL (2008) An Introduction to the Economics of Forest Disturbance. In: Holmes TP, Prestemon JP, Abt KL (eds.) The Economics of Forest Disturbances – Wildfires, Storms, and Invasive Species. Forestry Sciences, vol. 79, p. 3–14
Izhaki I, Adar M (1997) The effects of post-fire management on bird community succession. Int J Wildland Fire 7:335–342
JRC (2009) Review of the methodologies for the assessment of economic impacts of forest fires and economic efficiency of fire management. In: Pettenella D, Florian D, Mavsar R, Goio I, González-Cabán A (eds.) JRC – ISE, Ispra, p 108
Kaldor N (1939) Welfare propositions of economics and interpersonal comparisons of utility. Econ J 49:549–552

Kanninen BJ (ed) (2007) Valuing Environmental Amenities Using Stated Choice Studies. In: Bateman IJ (ed.) Springer. Dordrecht, The Netherlands

Kent B, Gebert K, McCaffrey S, Martin W, Calkin D, Schuster E, Martin I, Wise Bender H, Alward G, Kumagai Y, Cohn PJ, Carroll M, Williams D, Ekarius C (2003) Social and economic issues of the Hayman Fire. In: Service UF (ed.) General technical report RMRS-GTR. USDA Forest Service, pp 315–396

Kochi I, Loomis JB, Champ P, Donovan GH (2008) Health and economic impact of wildfires: literature review, III international symposium on fire economics, planning and policy: common problems and approaches, Carolina, Puerto Rico

Lamb D (2009) Economic, social and cultural factors affecting landscape restoration. In: Bautista S, Aronson J, Vallejo VR (eds) Land restoration to combat desertification. CEAM, Valencia, pp 35–46

Loomis J (2004) Do nearby forest fires cause a reduction in residential property values? J For Econ 10:149–157

Loomis JB, Englin J, Gonález-Cabán A (1999) Effects of fire on the economic value of forest recreation in the Intermountain West: preliminary results. In: Gonález-Cabán A, Omi PN (eds.) Symposium on fire economics, planning, and policy: bottom lines. USDA Forest Service, Pacific Southwest

Loomis JB, Englin J, Gonález-Cabán A (2001) Testing for differential effects of forest fires on hiking and mountain biking demand and benefits. J Agr Res Econ 26:508–522

Marques MA, Mora E (1998) Effects on erosion of two post-fire management practices: clear-cutting versus non-intervention. Soil Till Res 45:433–439

Mas-Colell A, Whinston M, Green J (1995) Microeconomic theory. Oxford University Press, Oxford

Mavsar R, Riera P (2007) Valoración Económica de las Principales Externalidades de los Bosques Mediterráneos Españoles: Informe final. Ministerio de Medio Ambiente, Barcelona, p 93

Mavsar R, Farreras V, Kovac M, Japelj A (2009) Written description of the private and social evaluation models. Deliverable D4.5-2 of the Integrated project "Fire Paradox", Project no. FP6-018505, European Commission, p 76

Mayer A (1995) Forest valuation for decision making: lessons of experience and proposals for improvement. Food and Agriculture Organization of the United Nations, Rome, February 1997

Mercer DE, Jeffrey PP, David TB, John MP (2007) Evaluating alternative prescribed burning policies to reduce net economic damages from wildfire. Am J Agric Econ 89:63–77

Merlo M, Croitoru L (2005) Valuing Mediterranean forests: towards total economic value. CABI Publishing, Wallingford

Molina JR, Rodriguez Y, Silva F, Herrera MA, Zamora R (2009) A simulation tool for socio-economic planning on forest fire suppression management. In: Gomez E, Alvarez K (eds) Forest fires: detection, suppression and prevention. Nova Science Publishers Inc, New York

Monteil C, Herrero G, (2010) An overview of policies and practices related to fire ignitions at the European Union level. In: Sande Silva J, Rego F, Fernandes P, Rigolot E (eds.) Towards integrated fire management – outcomes of the European Project Fire Paradox. European Forest Institute Research Report 23, 2010

Morgera E, Cirelli MT (2009) Forest fires and the law. A guide for national drafters based on the fire management voluntary guidelines. FAO, Rome

Mueller J, Loomis J, González-Cabán A (2007) Do repeated wildfires change homebuyer's demand for homes in high risk areas? A hedonic analysis of the short- and long-term effects of repeated wildfires on home prices in southern California. J Real Estate Finan Econ 38:155–172

Napoleone C, Jappiot M (2008) Et si l'efficacité de la lutte contre les incendies jouait comme une incitation aux comprtements les plis risqués? Forêt méditerranéenne 29 (1):3–11

Navrud S (2001) Valuing health impacts from air pollution in Europe. Env Res Econ 20(4):305–329

OECD (2000) Services: statistics on value added and employment, OECD 2000 edition, Introduction, p 11

Portugal's Decree-Law No. 139/88; Bulgaria's Forest Law, Prom. SG. 125/29 Dec 1997, amend. SG 16/03, Art.42

Prestemon JP, Holmes TP (2004) Market dynamics and optimal timber salvage after a natural catastrophe. For Sci 50(4):495–511

Riera P, García D, Kriström B, Brännlund R (2005) Manual de Economía Ambiental y de los Recursos Naturales. International Thomson Editores Spain. 355 pp

Riera P, Mavsar R, Mogas J (2008) Forest fire valuation and evaluation: a survey. In: Cesaro L, Gatto P, Pettenella D (eds) The multifunctional role of forests – policies, methods and case studies. European Forest Institute, Padova, pp 367–380

Rittmaster R, Adamowicz WL, Amiro B, Pelletier RT (2006) Economic analysis of health effects from forest fires. Can J For Res 36:868–877

Rosenbaum KL (2007) Legislative drafting guide: a practitioner's view. FAO Legal Paper (on-line) #64 (available at www.fao.org)

Ryan RL, Hamin E (2006) Engaging communities in post-fire restoration: Forest treatments and community-agency relations after the Cerro Grande Fire. In McCaffrey S (ed.) The public and wildland fire management: social science findings for managers. General technical report, NRS-1. USDA Forest Service, Northern Research Station, Newtown Square, pp 87–96

Ryan RL, Hamin E (2007) After the fire: local residents' perceptions of post-fire forest restoration. In: Extended abstracts from the human dimensions of wildland fire conference, 10/23-25, Colorado S, McCaffrey P, Woodward M, Robinson, compilers. International Association of Wildland Fire, Fort Collins pp 54–56

Sandberg DV, Ottmar RD, Peterson JL, Core J (2002) Wildland fire on ecosystems: effects of fire on air, Gen. Tech. Rep. RMRS-GTR. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT, p 79

Smith JK (2000) Wildland fire in ecosystems: effects of fire on fauna, Gen. Tech. Rep. RMRS-GTR. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT (USA), p 83

Spanos I, Raftoyannis Y, Goudelis G, Xanthopoulou E, Samara T, Tsiontsis A (2007) Effects of post-fire logging on soil and vegetation recovery in a Pinus halepensis Mill. forest of Greece. Eco- and Ground Bio-Engineering: the use of vegetation to improve slope stability developments in plant and soil sciences 103:345–352

Sugden R, Williams A (1978) The principles of practical cost-benefit analysis. Oxford University Press, Oxford

US.EPA (2004) Air quality criteria for particulate matter (final report, Oct 2004). In: Agency UEP (ed.) US Environmental Protection Agency, Washington D.C

Vega JA, Fernández C, Pérez-Gorostiaga P, Fonturbel T (2008) The influence of fire severity, serotiny, and post-fire management on Pinus pinaster Ait. recruitment in three burnt areas in Galicia (NW Spain). For Ecol Manag 256:1596–1603

Velez R (2000) La defensa contra los incendios forestales: Fundamentos y experiencias. McGraw-Hill Inc., Madrid

Velez R (2009) The causing factors: a focus on economic and social driving forces. In: Birot Y (ed) Living with wildfires: what can science tell us. EFI Discussion Papers, 15, p 21–26

Wade DD, Lunsford JD (1988) A guide for prescribed fire in southern forests, Technical Publication R8-TP. USDA Forest Service, Southern Region, Atlanta, p 56

Zybach B, Dubrasich M, Brenner G, Marker J (2009) U.S. Wildfire Cost-Plus-Loss Economics Project: the "One-Pager" checklist. John Wildland Fire Lessons Learned Center, p 20